Characteristics

The effectiveness of data comm. system depends upon

1. Delievery
2. Accuracy
3. Timeliness – real time transmission
4. Jitter – variation in packet arrival time.

Components of Data comm. Systems

1. Message
2. Sender
3. Reciever
4. Transmission Medium
5. Protocol – a set of rules that govern d comm. → agreement b/w comm. devices
→ without protocol devices can be connecte but can't communicate

Transmission Modes

19 SUNDAY

1. Simplex
2. Half duplex.
3. Full duplex

INTERNET Services

NETWORK FUNCTIONS

A computer NW means interconnected collection of autonomous computers.

A collection of interconnected computers & facilities that provides transfer of information between users located at various geographical points.

Objectives of NW:

1. CONNECTIVITY: should be there to provide interconnection with each other.
2. SIMPLICITY: should be there to permit all operations properly.
3. MODULARITY: dividing whole NW into modules gives easy installation & easy to debug error and work properly.
4. RELIABILITY: achieved with the help of backup & redundancy. It helps in error detection & correction.
   "Reliability means errors in one area should not affect others".
5. FLEXIBILITY: modification can be done easily to adopt new technology and for future expansion.

⑥ **DIVERSITY:** It means diff. kinds of services are available on NW for user to use without knowing implementation of NW.

⑦ **SECURITY:** should be there to avoid unauthorized access.

• **Applications/Uses of NW:** A major goal of NW is to provide resource sharing & to provide reliable, low cost facilities & easy addition of new processing services.

1. Sharing of distant resources.
2. Interprocess communication
3. Reliability of NW
4. Distribution of processing function
5. Centralized management & allocation of NW resources
6. Efficient means of transporting large volume of data
7. Flexible working environment.

Network for companies:

→ resource sharing
→ high reliability
→ saving money
→ high scalability
→ powerful communication

→ Connection b/w computing devices can be wired or wireless using radio waves or infrared signals.

Data Transfer Rate (Bandwidth):- The speed at which data is moved from one place to another

Network for People:

→ access to remote information
→ person to person communication
→ interactive environment.

Network And Services:

① Radio & Television Broadcasting -

Most common communication service. Various stations transmit signals simultaneously over radio or cable distribution NW. Aside from selecting the station of interest, the role of user in these services is passive. Relatively high audio & vedio quality is expected; but a significant amount of delay can be tolerated.

② Telephone Service -

Most common real-time service provided by a NW. Two persons are able to communicate by transmitting their voices across the NW. This service is "connection-oriented" means users must first interact with the NW to setup a connection. There should be high degree of availability, security & privacy.

M T W T F S S
1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30 31

③ Cellular telephone Service :

Extends normal telephone service to mobile users who are free to move within a regional area covered by an interconnected array of smaller geographical areas called CELLS. Each cell has a radio transmission system that allows it to communicate with users in its area. It provides lower voice quality & lower availability. Some cellular providers support a roaming service where a subscriber is able to place calls while visiting regional areas other than the subscribers home base.

④ Electronic Mail :

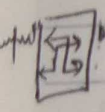
User typically provides a text msg & a name or address to a mail application. The application interacts with a local mail server which in turn transmits the msg to destination server across a comm. Nw. The destination user retrieves the msg by using a mail application. E-mail is not real-time or not necessarily connection-oriented.

⑤ Vedio on Demand :

FUNCTIONS OF A NW :

The essential func". of a NW is to transfer information between a source & destination. The functions that a N/W must provide :

1. **Basic User Services :** The primary service that a NW must provide to its users is communication, sharing of resources.
2. **Switching Approach :** The means of transferring info. flows between communication lines. Switches transfer the information from 1 transmission line to another.



3. **Terminal :** The end system that connects to the NW
4. **Information Representation :** The format of the information handled by the NW. NWs are typically designed to carry specific types of information representation. eg. analog voice signals, bits or characters.
5. **Transmission system :** The means for transmitting info across a physical medium. eg. wires, cables, radio, optical fibre.
6. **Addressing :** The means for identifying points of connection to the NW. Addressing is required to identify which NW input is to be connected to which NW output.

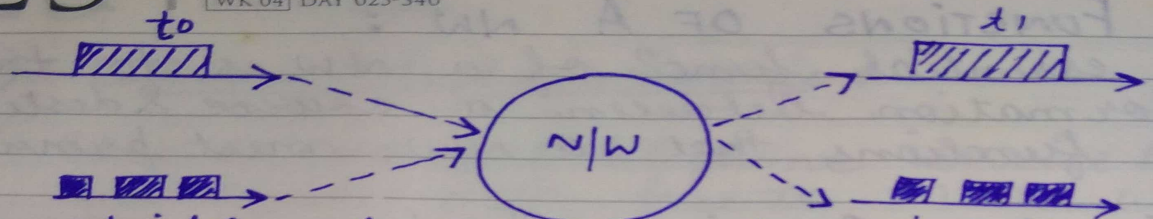


fig (1) A N/W transfer info among users

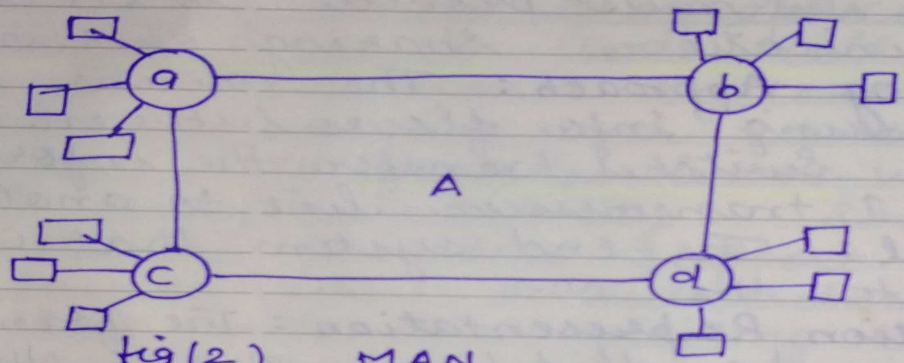
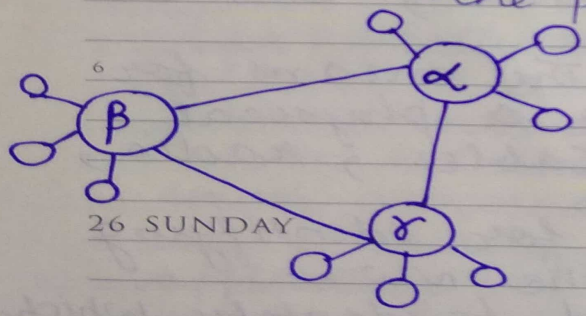


fig (2) MAN

7. Routing : The means for determining the path across the NW.



α. A. a. 1 → The use of heirarchical addressing facilities for task of routing

26 SUNDAY

Success seems to be largely a matter of hanging on after others have let go.

8. **Multiplexing:** The means for connecting multiple information flows into shared connection lines.

9. **Traffic Control:** To ensure smooth flow of information through the NW. In addition, when congestion occours inside the NW as a result of a surge in traffic or a fault in equipments, the NW should react by applying congestion or overload control.

10. **Network Management:** Includes monitoring the performance of the NW, detecting & recovering from faults, configuring the NW resources & providing security by controlling access to the information that flows in the Network.

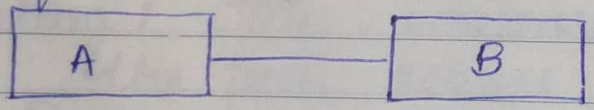
28 | TUESDAY
WK 05 DAY 028-337

NETWORK TOPOLOGY:

→ means physical structure in which all components of NW are connected
→ desc. the method used to do the physical wiring of NW
→ also indicates how many devices can be connected.

Two types of connection are:
1) Point-to-point
2) Multipoint.

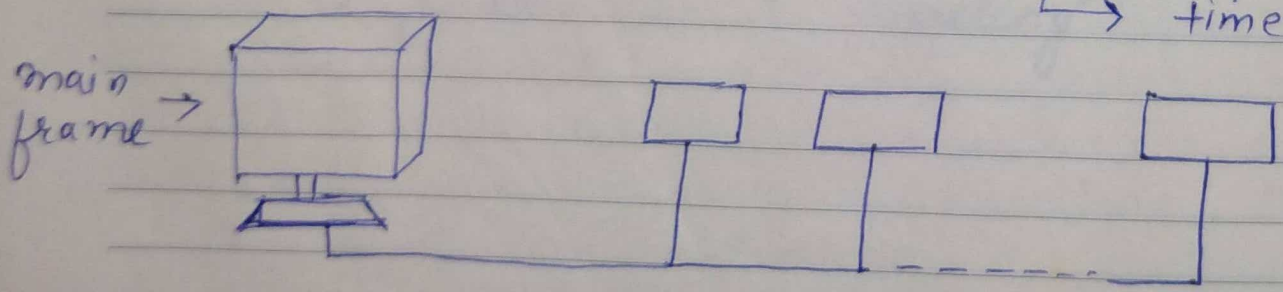
Point-to-Point Connection: Direct link is used b/w two devices in dedicated way to transfer. It uses entire capacity of transmission media to transfer.



→ actual length
→ Infrared remote control

Multipoint: links 3 or more devices. Generally, it uses one master computer & a series of slave terminals. All terminals share bandwidth of transmission media.

→ Spatial
→ time shared



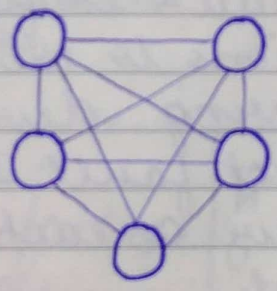
Properties Considered for Selecting Topology:

1. Ease of installation
2. Ease of configuration
3. Ease of troubleshoot
4. No. of units affected in case of media failure.

Types of topology:

1. Mesh
2. Star
3. Tree
4. Bus
5. Ring
6. Cellular

① **Mesh Topology**: have dedicated point-to-point link between devices. A fully connected mesh NW has $n(n-1)/2$ physical channels to connect 'n' devices. Every device has (n-1) I/O ports.



Advantages:

→ high speed
→ eliminates traffic problem
→ Its robust means not prone to crash
→ Privacy is maintained
→ Fault identification is easy

Disadvantages:

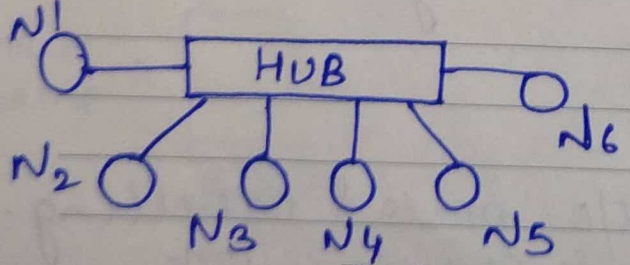
→ costly
→ too much requirement of I/O ports & cabelling.
→ difficult installation & reconfiguration

(2) **Star Topology**: is designed with each node connected directly to a centrally located device or hub. Hub is a spl. kind of repeater that overcomes the electromechanical limitations of media. Data passes through hub before continuing to its destination. The hub manages/ controls all functions of a NW. It also acts as a repeater for data flow. Hub resends message to computer.

1) Broadcasting: When hub transfer data to all
2) Unicasting: When hub transfers data to single node.

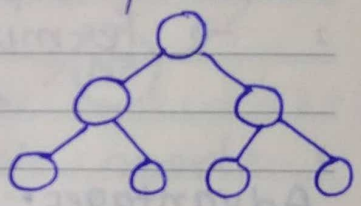
Advantages:

→ Easy to install & configure
→ No disruptions to the NW when connecting/ removing devices.
→ Easy to detect fault & remove faults
→ Less expensive as each device needs 1 link & 1 port
→ A computer failure doesn't affect whole NW
→ Ordinary telephone cables, ~~US~~ UTP, STP can be used.



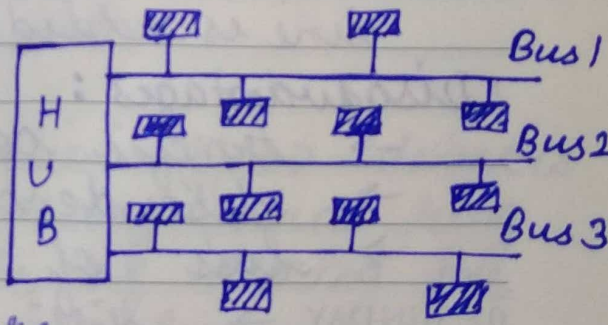
Disadvantages:
→ failure of hub brings entire NW down
→ More cabling is required than ring/bus
→ Slower than Mesh.

③ **Tree Topology:** (HYBRID TOPOLOGY)
Combines the characteristics of linear bus & star topology. It is similar to star NW that nodes are connected to the secondary hub that inturn connected to central hub. Central hub behaves as active or passive hub.



Advantages:
→ Point to point curing for individual segments
→ Supported by several HW and SW vendors

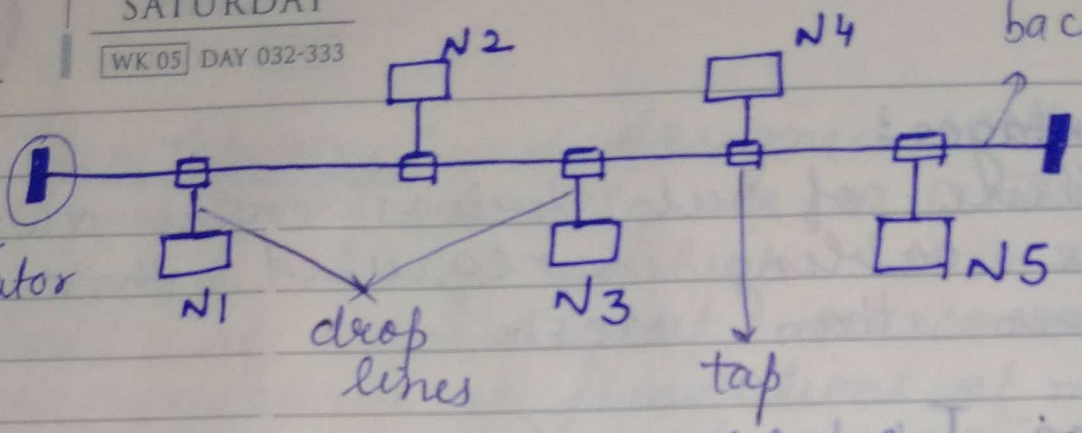
Or



Disadvantages:
→ If central hub fails, entire segment goes down
→ More difficult to configure & wire.

④ **Bus topology:** A long cable is used as a link or backbone to connect all devices.

01 | SATURDAY
WK 05 DAY 032-333



→ A drop line is a cable running between device & main cable.
→ A signal becomes weak when it travels in main cable. So there is a limited no. of devices that can be connected to backbone.
→ Terminators absorb electrical energy & stop reflections.

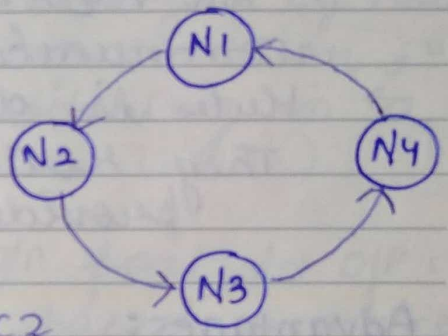
Advantages:
→ Reliable, simple, easy to use
→ easy to install, cheaper than others
→ less labelling is used bcz each drop ~~line~~ line is added to nearest point to cable.

Disadvantages:
→ traffic conjunction
→ dependency on main cable
→ loss of information
→ difficult fault isolation.

02 SUNDAY

(5) **Ring Topology:** Each device has dedicated point to point link configuration only with 2 devices on either side of it.

→ The communication is only 1 directional until info. reaches to destination. When the device receives the signal intended for other node. It simply regenerates the bits & passes them along. Ring NW passes a token (A short message with the electronic address of receiver)



Advantages:
→ easy to install & configure
→ adding & deleting new devices is easy
→ no loss of information bcz token is regenerated at each node
→ no terminators are required.

Disadvantages:
→ A break in ring stops entire transmission
→ difficult to troubleshoot

2-way ring: Two connections b/w 2 devices gives high reliability. using dual ring NW or a switch capable of closing the break can solve the problem.

⑥ Cellular Topology:

Used in application of wireless media that does not require any kind of cable connection.

FEBRUARY 2014

04 | TUESDAY
WK 06 DAY 035-330

FEBRUARY 201

M	T	W	T	F	S
					1
3	4	5	6	7	8
10	11	12	13	14	15
17	18	19	20	21	22
24	25	26	27	28	

→ Total area is divided into a no. of small areas, each area called CELL.

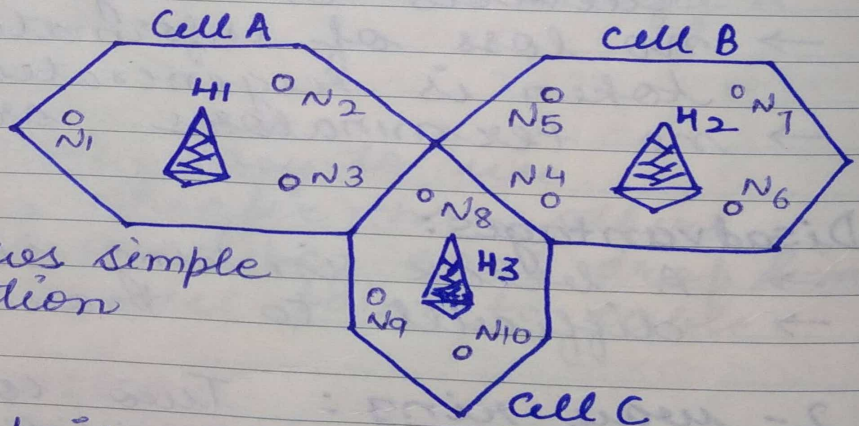
→ In wireless media, each point transmits in a certain geographical area called a cell. Each cell represents a portion of the total NW area. Devices that are in the cell communicate through a central hub.

→ Hubs in diff cells are interconnected. They route data across the NW and provide a complete NW.

Advantages:

→ troubleshooting is easy

→ hub to hub fault tracking is more difficult but allows simple fault identification



Disadvantages:

→ If central hub fails all nodes in that range are affected.

Switching Approaches :

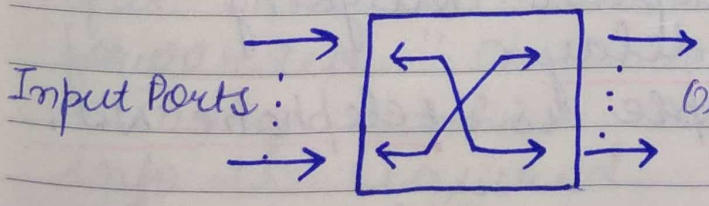
Switching is very important technique which enhances the communication process by providing an independent path which is collision free. It decides which path is followed for transmission.

These approaches are characterized by how info. is organized ~~by~~ for transmission, multiplexing, routing & switching in a Network.

→ Switch forwared frame I/P port to O/P port. Port is selected based on address in frame header.

→ Switches are capable of creating temporary connections b/w two or more devices linked to switch.

Switched NW : consists of series of interlinked nodes.

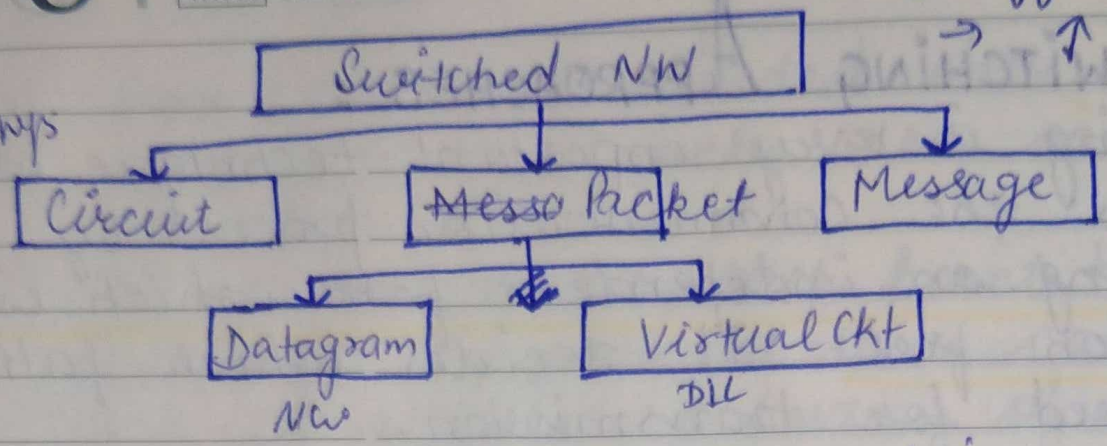


Switching approaches are of various types:

1) Ckt. switched NW
2) Message " "
3) Packet " "
4) Virtual " "

06 | THURSDAY
WK 06 DAY 037-328

→ Phys. layer
→ Contiguous flow
→ No
→ ↓ efficiency
→ ↑ Delay



It determines how connections are made & how data movement is handled.

① CIRCUIT SWITCHING:

dedicated path

A dedicated comm. path is established b/w two stations through nodes of the NW. The path is a connected sequence of physical links b/w nodes. On each link, a logical channel is dedicated to the connection. Data generated by source stations are transmitted along dedicated path as rapidly as possible. At each node, incoming data are routed or switched to the appropriate outgoing channel without delay.
Most common example is telephone NW.

Thus, in ckt switching, a msg is transferred by providing a complete path of transmission lines from originating node to destination node. A particular ckt is established by sending special signal to nodes. When comm is over, then ckt is delivered.

CS → MS → PS
1960

Setup time + TT + PD + Tear Down time

There is no concept of store & forward delay.

9 → Dedicated HW connection b/w sender & receiver

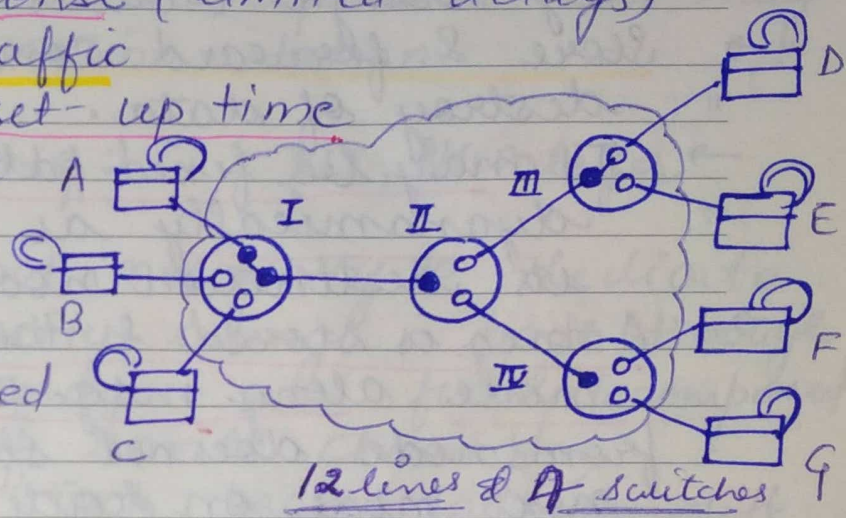
10 → Real-time NW response (limited delays)
→ Good for Burst traffic

11 → Relatively large set-up time
→ 10 sec setup time

12 → Copper paths
→ full bandwidth

1 → No buffer is used.
→ Complexity is reduced

2 using switch.



12 lines & 4 switches

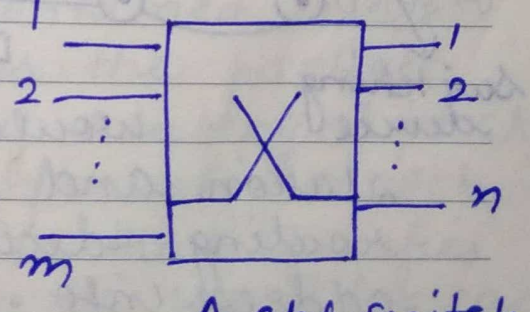
3 Telephone NWs are connection oriented bcz they require setting up a connection before actual

4 transfer of information can take place.
In ckt. switching, the routing decision

5 is made when path is set up across NW.

6 After the call has been setup, the info. is forwarded "continuously" across each switch in the path. No additional address info is required

→ reliable
→ no loss of data
→ no resequencing or reassembling is done on Rx
→ slow comparatively.



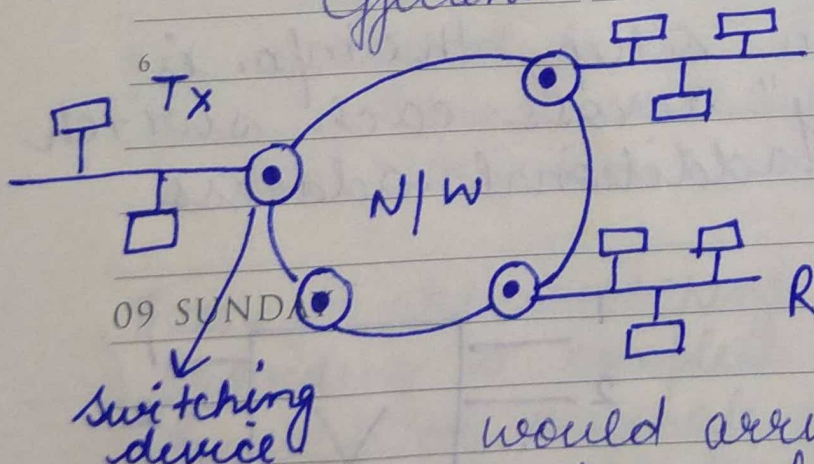
A ckt. switch

→ Predecessor of packet
→ Store & forward
→ Hop by Hop delivery

(2) MESSAGE SWITCHING :

→ Transfers msg among nodes by moving the msg through various links & msg buffer.
→ Store & forward concept is used to avoid destroy of data.
→ It may be fixed path or may be described dynamically as msg flows towards its destination node.
→ A msg is stored & then transmitted to next node along msg path. A msg transmission from node does not start until a buffer at next node on route has been allocated for it.

This type of NW is also called store & forward NW. There is possibility of msg congestion & queuing in nodes. Message delay is more. It's more efficient & more reliable.



In telegraph NW, the text msg is transmitted over long distance using morse code. Here a msg or telegram would arrive at a telegraph switching station and an operator would make a routing decision based on destination address info. The operator would then

store msg until comm. line becomes available to forward the msg to the next appropriate station.

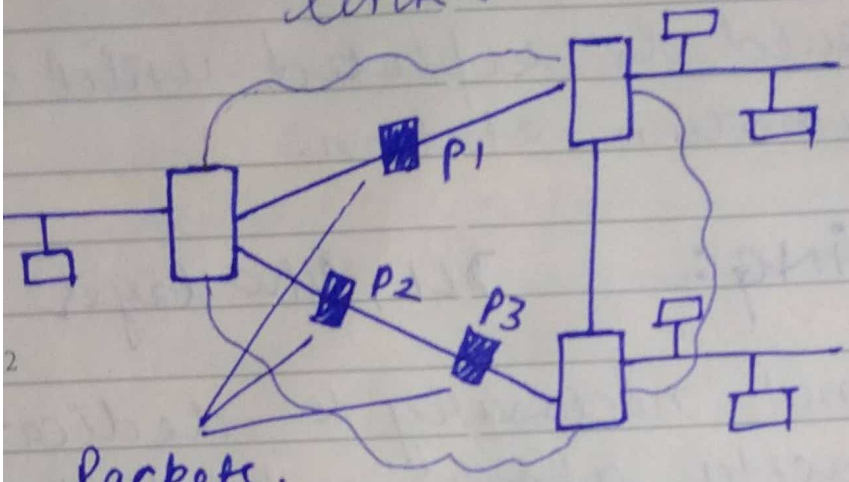
This process would be repeated until msg arrives at destination station.

③ PACKET SWITCHING: DLL, N/W layer

In this case it is not necessary to dedicate transmission capacity along a path through the N/W. Long messages are firstly decomposed into a sequence of small chunks, called PACKETS. Each packet follows diff route until it reaches to destination. At each node, the entire packet is received, stored briefly & then transmitted to the next node.

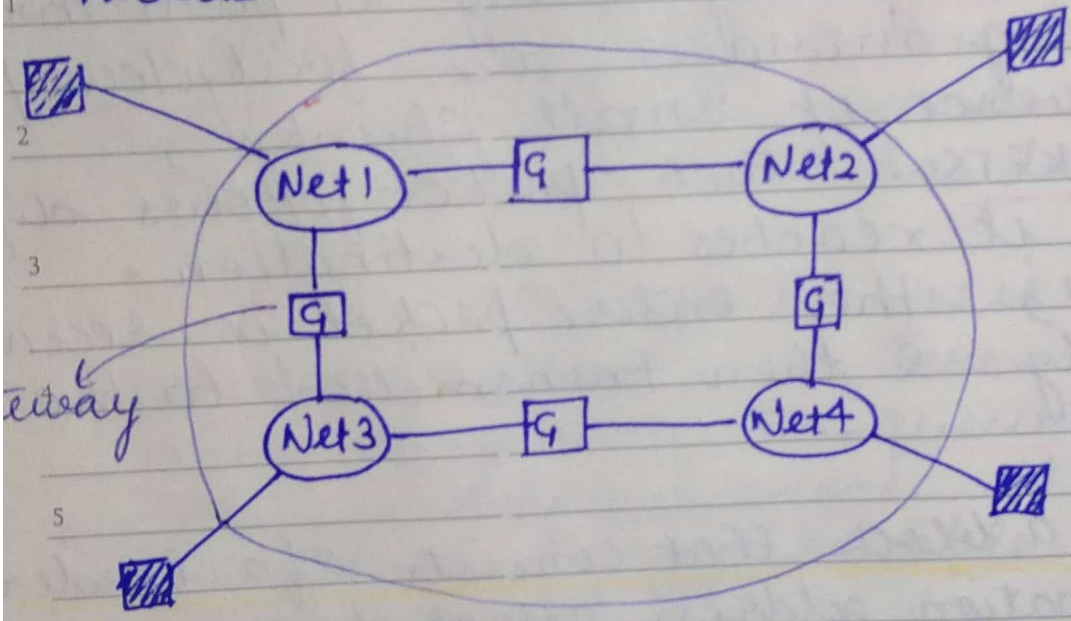
A packet is a block that consists of a header with a destination address attached to user info & is transmitted as a single unit across a NW. It is connection less, means no conn. is setup prior to transmission of packets. Each packet or datagram contained dest^{n}. address info that enables the packet switches in N/W to carry routing of packet to the destination. Each packet switch maintains a routing table that specifies the output line that is to be used for each

given destination. Packets are buffered to await transmission on appropriate link.



Packets.

→ data link & n/w layer
→ Store & for.
→ Pipelining
→ efficiency
→ Delay



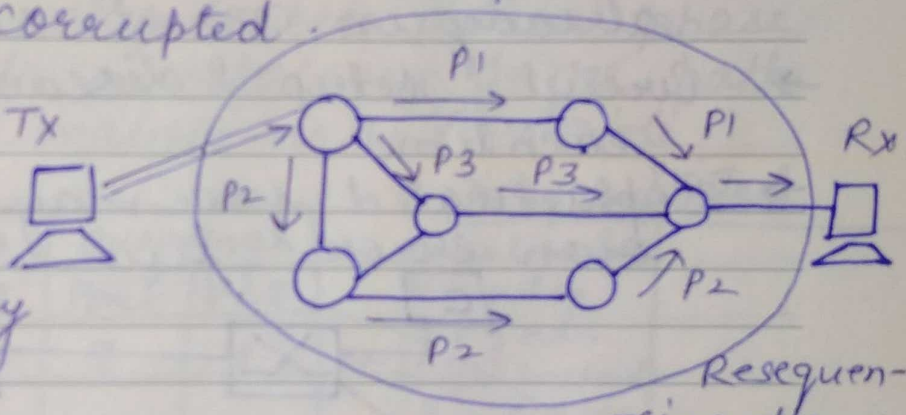
Internetwork

IP (internet protocol) was developed to provide connection less transfer of packets across the interconnected NW. In IP, the component NWs are interconnected by special packet switches called gateways/routers. IP routers direct the transfer of IP packets across an internet.

Total time = n(TT) + PD (PD: Propagation Delay)

After a routing decision is made, the packets are placed in a buffer to await transmission over next NW. IP provides best effort service means IP makes every effort to deliver the packets but takes no additional actions when packets are lost or corrupted.

every packet routed independently

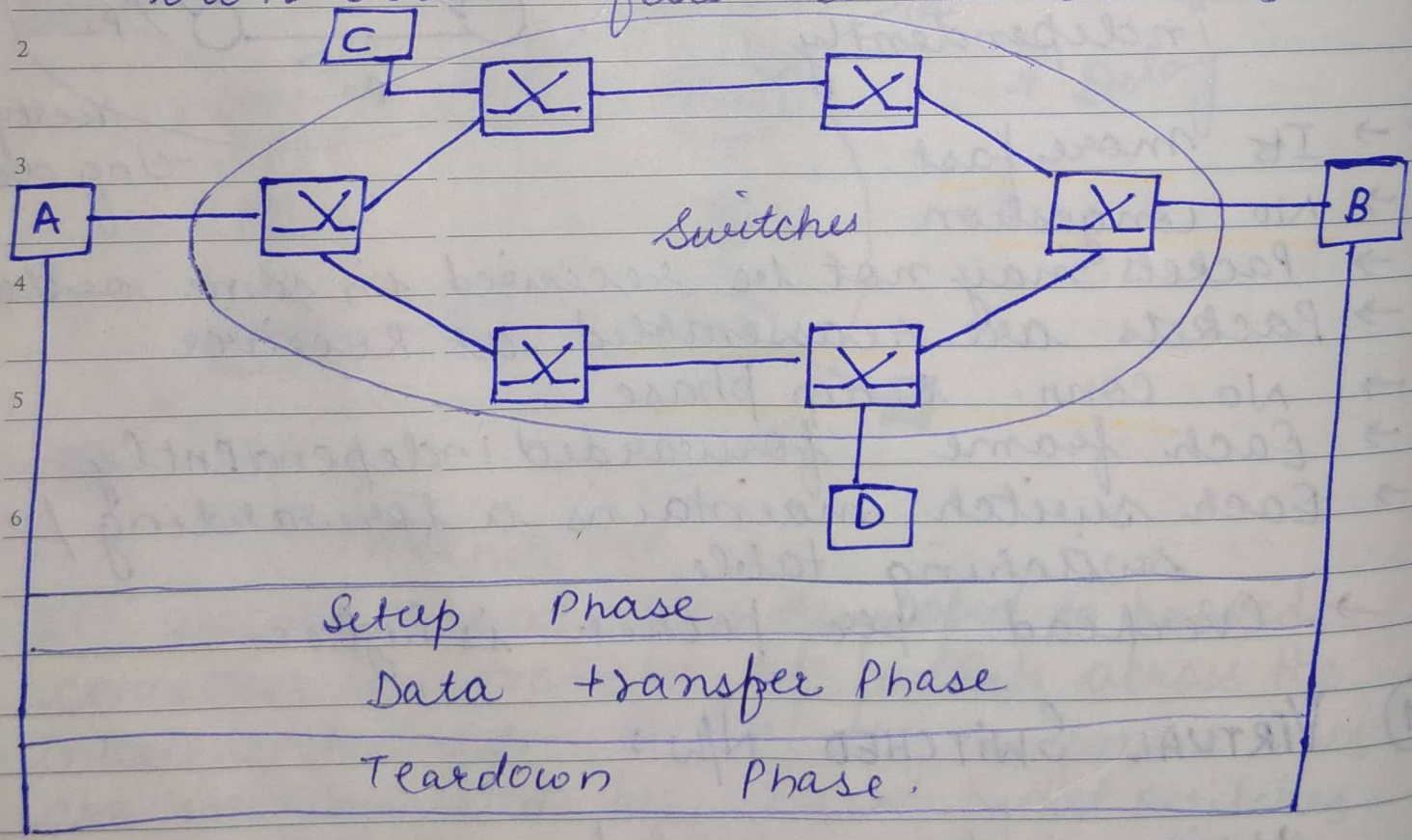


→ Its more fast
→ No congestion
→ Packets may not be received in same order
→ Packets are reassembled at Receiver
→ No conn. setup phase
→ Each frame forwarded independently
→ Each switch maintains a forwarding/switching table
→ Overhead per packet is higher.

④ VIRTUAL SWITCHED N/W:

Message is broken into packets. The packets through this switching are stored & forwarded from node to node. No path established initially. The first packet which is

transmitted initially forms a virtual ckt & other packets follow it. Its fast enough for interactive communication.
→ No reassembling of packets is required.
→ Easier for user hosts to use as the data is already in correct sequence
→ Circuit setup & disconnection is required each time.
→ Sophisticated user may want to do their own error & flow control schemes.



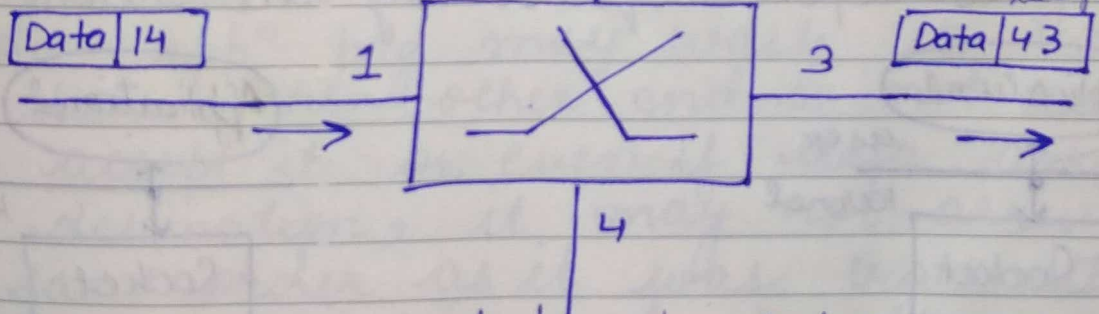
Setup Phase
Data transfer Phase
Teardown Phase.

Based only on a label with the packet header, only packets whose "virtual ckt" has been

set up ahead of time must be forwarded correctly.
→ labels are not destination add", usually much shorter.
→ Labels need to be unique on a link but not in a N/W.
→ Explicit conn. setup & tear down phase
→ subsequences frames follow same path
→ Each switch maintains a VC table.

Incoming		Outgoing	
Port	VCI	Port	VCI
1	14	3	43

Datagram	Virtual
connection less	
no generation	
out of order	
High overhead	
Packet lost ↑	↓
eg. Internet	X.25, ATM
high off	high cost



→ Low overhead per packet as compared to packet switching
→ Switch forwarding table consists of a map between (input port, packet) to (output port, new packet label).

→ Frame relay, ATM, X.25, MPLS.

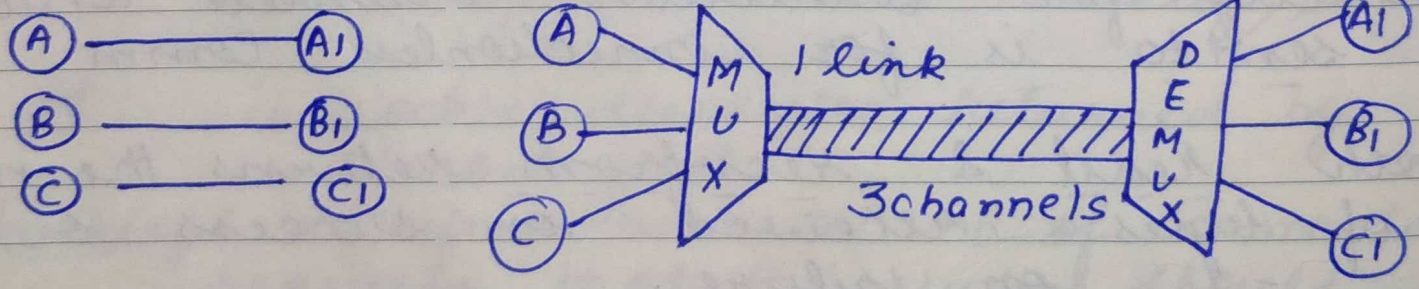
MULTIPLEXING :

This technique is used for sharing of expensive transmission resource by several connections or info flows.

We share bandwidth of media among a community of users. It allows the simultaneous transmission of multiple signals across a single data link.

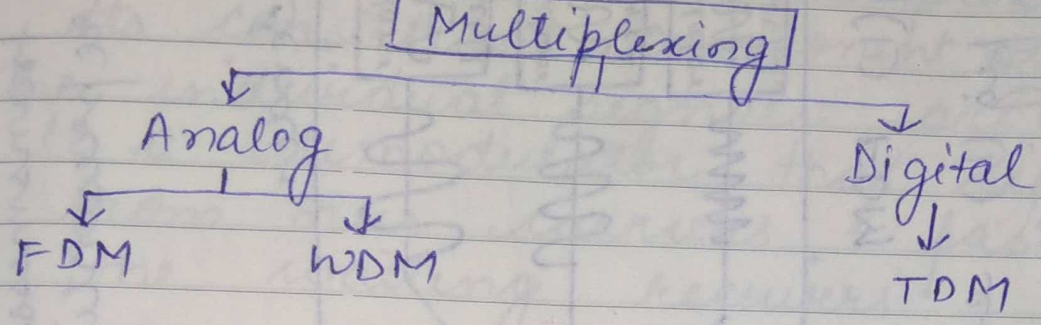
If Bandwidth of a link is greater than the BW of devices connected to it; the BW is wasted.

In a multiplexed system, n lines share Bandwidth of 1 link.



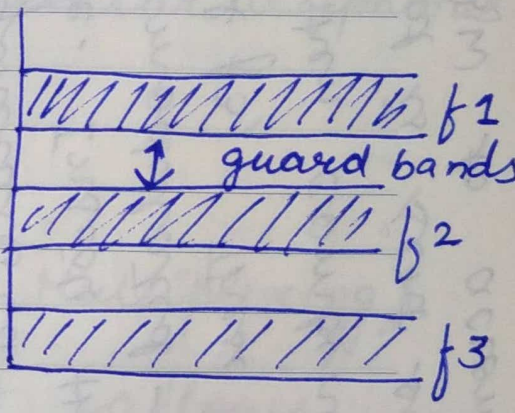
The 3 lines on left direct their transmission stream to a multiplexer which combines them into a single stream. At receiver's end, that stream is fed into a demux, which separates the stream back into its components & directs them to their corresponding lines.

Categories of Multiplexing



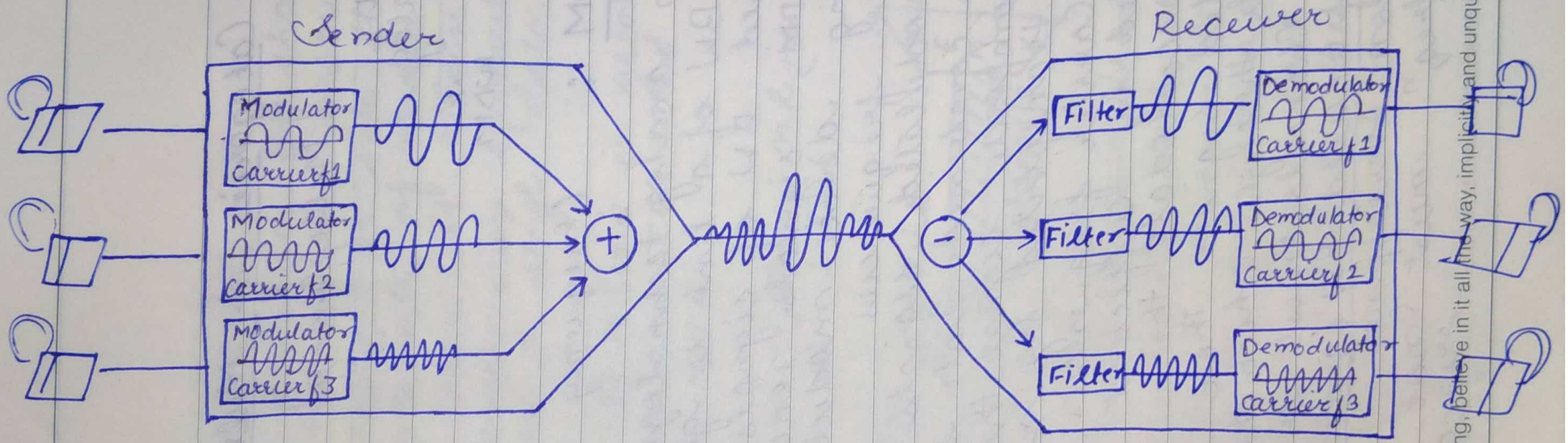
FDM : (Frequency Division Multiplexing)

It is an analog technology that can be applied when BW of a link is greater than the combined BW of signals to be transmitted. In FDM, signals generated by each sending device modulate different carrier frequencies. These modulated signals are then combined into a single composite signal that can be transported by a link. Carrier frequencies are separated by sufficient BW to accomodate the modulated signal. These BW ranges are the channels through which the various signals travel. Channels must be separated by strips of unused BW (guard Bands) to prevent them from overlapping.



Carrier freq". must not interfere with original data frequency.

The transmission path is divided into 3 parts, each representing a channel to carry one transmission.



fig(1) FDM

In fig(1) each telephone generates a signal of a similar frequency range. Inside the multiplexer, these similar signals are modulated onto diff carrier frequencies (f1, f2 & f3). These resulting modulated signals are then combined into a single composite signal that is sent out over a media link that has enough BW to accomodate it.

The demultiplexer uses a series of filters to decompose the multiplexed signal into its constituent component signals.
The individual signals are then passed to a demodulator that separates them from their carriers & passes them to the waiting receivers.

APPLICATIONS OF FDM:

1) A very common application of FDM is AM & FM radio broadcasting. Radio uses air as the transmission medium.
2) Another common use of FDM is in television Broadcasting.
3) First generation of cellular telephones also uses FDM.

TDM: (time - division Multiplexing)

It is a digital process that allows several connections to share the high Bandwidth of a link. Instead of sharing a portion of the BW as in FDM, time is shared.
Each connection occupies a portion of time in the link.

01 | SATURDAY
WK 09 DAY 060-305

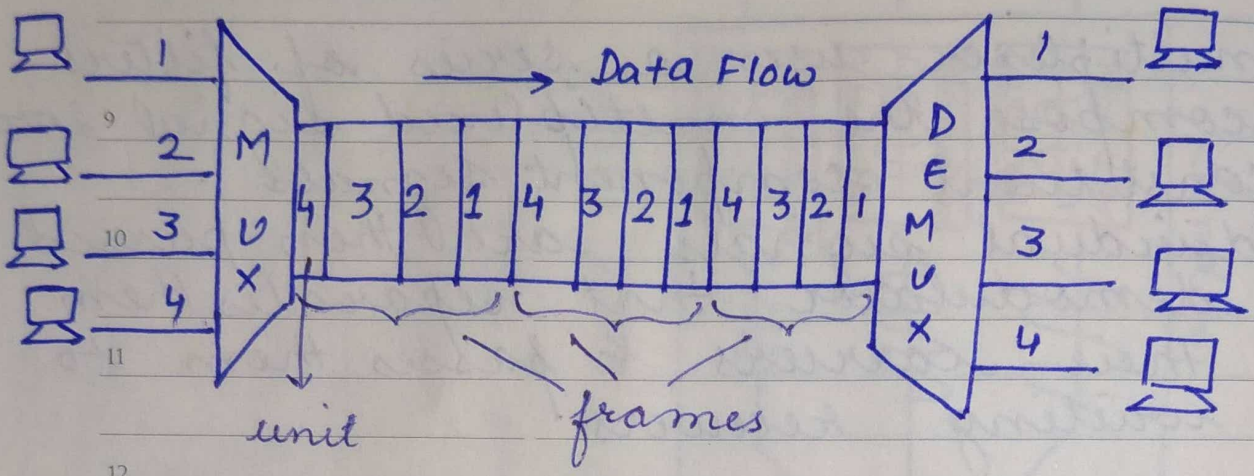


fig (2)

Time slots & frames : The data flow of each connection is divided into units & the link combines 1 unit of each connection to make a frame. The size of unit can be 1 bit or several bits. For n input connections, a frame is organized into a ~~mini~~ minimum of n time slots; each slot carrying 1 unit from each connection.

In TDM, the data rate of the link that carries data from n connections must be n times the data rate of a connection to guarantee flow of data. Therefore, the duration of a unit in a connection is n times the duration of a time slot in a frame.

02 SUNDAY

When firmness is sufficient, rashness is unnecessary.

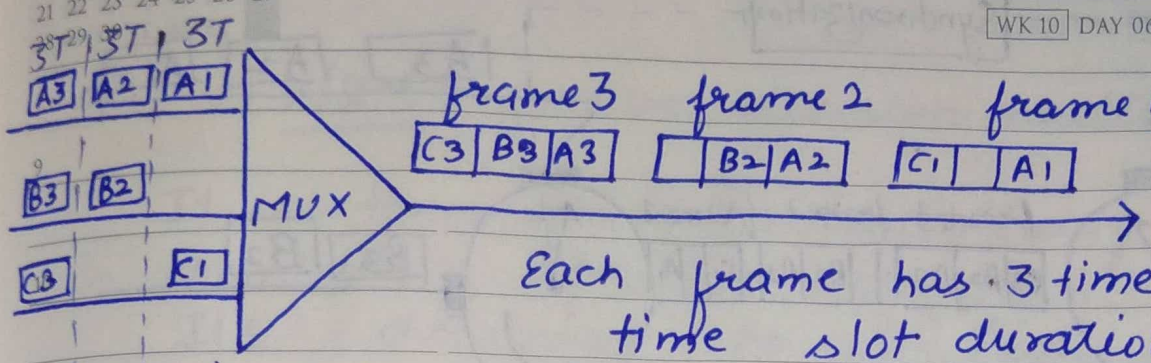


fig (3)

Each frame has 3 time slots. Each time slot duration is T sec.

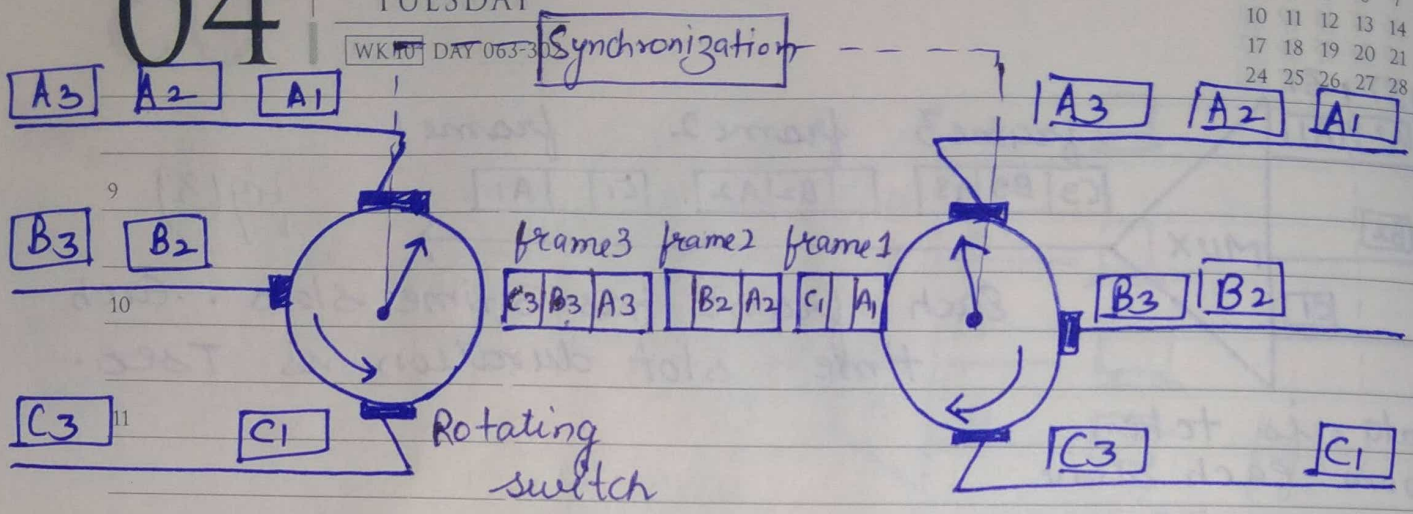
Data is taken from each line every 3T sec

TDM can be visualized as 2 fast rotating switches, one on the multiplexing side & other on demultiplexing side. The switches are synchronized & rotate at same speed but in opposite directions.
On the multiplexing side, as the switch opens in front of a connection, that Conn. has opportunity to send a unit onto path. This is called interleaving.

On the demultiplexing side, as the switch opens in front of a connection, that connection has opportunity to receive a unit from a path.

Fig (4) shows interleaving

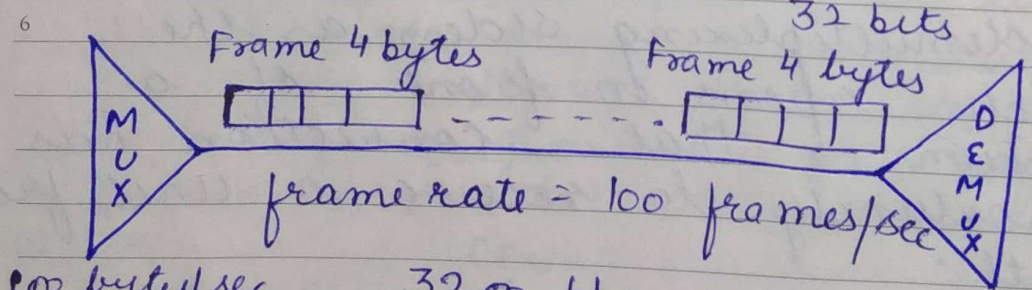
(next page)



fig(4) Interleaving

APPLICATION: Some 2nd generation cellular telephone companies use it.

eg Each channel sends 100 bytes/second & we multiplex 1 byte/channel. Show frame travelling on link, size of frame, duration of frame, frame rate, bit rate.



100 bytes/sec 3200 bps

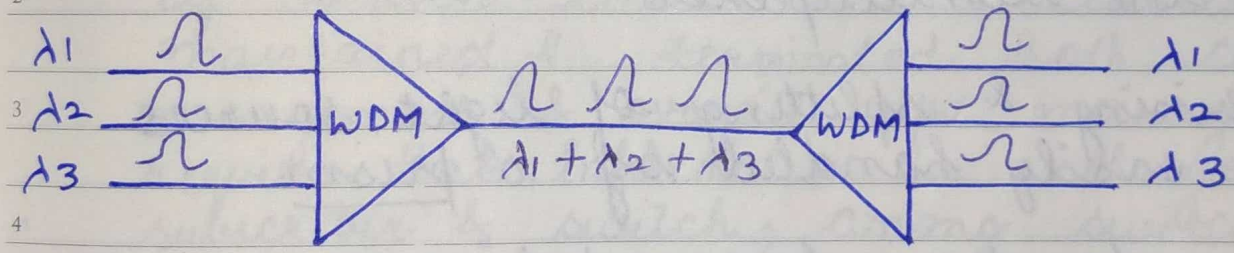
800 pps

frame duration = 1/100 sec

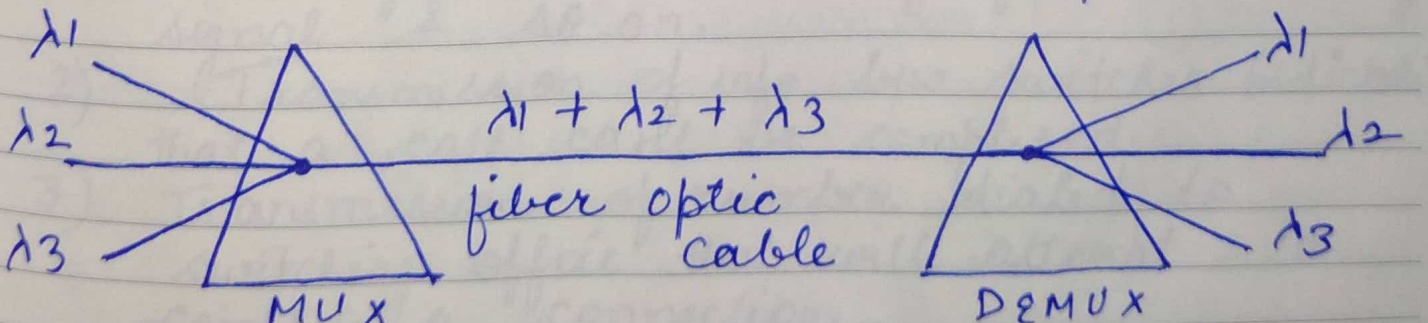
This is actually 4 times the bit rate for each channel, which is $100 \times 8 = 800$ bps

WDM: (Wave division multiplexing)

It is the analog multiplexing technique to combine optical signals.
It is designed to use high data rate capability of fiber-optic cable.
The optical fiber data rate is higher than data rate of metallic transmission rate.
Using a fiber optic cable for one single line wastes the available bandwidth.



WDM is an analog multiplexing technique to combine optical signals.
It is complex, but idea is simple.
It combine multiple light sources into one single light at the multiplexer & do the reverse at demultiplexer.



→ Dense WDM
→ SONET NW

WDM is conceptually the same as FDM, except that the multiplexing & demultiplexing involve optical signals transmitted through fiber - optic channel.
Very narrow bands of lights from different sources are combined to make a wider band of light.

At the receiver, signals are separated by the demultiplexer.

Combining & splitting of light sources are easily handled by a prism.

* Prism bends a beam of light based on the angle of incidence and the frequency.

APPLICATION:
SONET Network in which multiple optical fiber lines are multiplexed & demultiplexed.

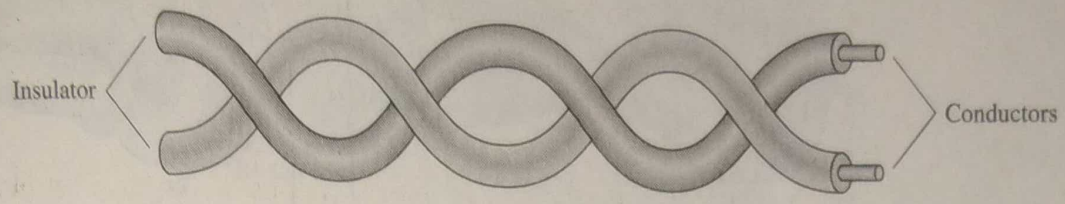
7.1 GUIDED MEDIA

Guided media, which are those that provide a conduit from one device to another, include **twisted-pair cable, coaxial cable,** and **fiber-optic cable.** A signal traveling along any of these media is directed and contained by the physical limits of the medium. Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current. **Optical fiber** is a cable that accepts and transports signals in the form of light.

Twisted-Pair Cable

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together, as shown in Figure 7.3.

Figure 7.3 *Twisted-pair cable*



One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two.

In addition to the signal sent by the sender on one of the wires, interference (noise) and crosstalk may affect both wires and create unwanted signals.

If the two wires are parallel, the effect of these unwanted signals is not the same in both wires because they are at different locations relative to the noise or crosstalk sources (e.g., one is closer and the other is farther). This results in a difference at the receiver. By twisting the pairs, a balance is maintained. For example, suppose in one twist, one wire is closer to the noise source and the other is farther; in the next twist, the reverse is true. Twisting makes it probable that both wires are equally affected by external influences (noise or crosstalk). This means that the receiver, which calculates the difference between the two, receives no unwanted signals. The unwanted signals are mostly canceled out. From the above discussion, it is clear that the number of twists per unit of length (e.g., inch) has some effect on the quality of the cable.

Unshielded Versus Shielded Twisted-Pair Cable

The most common twisted-pair cable used in communications is referred to as **unshielded twisted-pair (UTP)**. IBM has also produced a version of twisted-pair cable for its use called **shielded twisted-pair (STP)**. STP cable has a metal foil or braided-mesh covering that encases each pair of insulated conductors. Although metal casing improves the quality of cable by preventing the penetration of noise or crosstalk, it is bulkier and more expensive. Figure 7.4 shows the difference between UTP and STP. Our discussion focuses primarily on UTP because STP is seldom used outside of IBM.

Categories

The Electronic Industries Association (EIA) has developed standards to classify unshielded twisted-pair cable into seven categories. Categories are determined by cable quality, with 1 as the lowest and 7 as the highest. Each EIA category is suitable for specific uses. Table 7.1 shows these categories.

Connectors

The most common UTP connector is **RJ45** (RJ stands for registered jack), as shown in Figure 7.5. The RJ45 is a keyed connector, meaning the connector can be inserted in only one way.